Worked Examples using R, *Introductory Statistics, 7th ed.* by Neil Weiss

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Contents

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Abstract

This paper consists of the worked examples in each chapter of *Introductory Statistics, 7th Edition* by Neil Weiss, using the R programming language

1 The Nature of Statistics

1.1 Descriptive Statistics

This example contains no code.

1.2 Inferential Statistics

This example contains no code.

1.3 Classifying Statistical Studies

This example contains no code.

1.4 Classifying Statistical Studies

This example contains no code.

1.5 Simple Random Samples

```
#create vector of officials
library(prob)
off <- c('G', 'L', 'S', 'A', 'T')
#part a, list of samples of size 2
urnsamples(off, 2)
```

```
##    X1 X2
## 1   G  L
## 2   G  S
## 3   G  A
## 4   G  T
## 5   L  S
## 6   L  A
## 7   L  T
## 8   S  A
## 9   S  T
## 10  A  T
```

```
#part d, list of samples of size 4
urnsamples(off, 4)
```

```
##   X1 X2 X3 X4
## 1  G  L  S  A
## 2  G  L  S  T
## 3  G  L  A  T
## 4  G  S  A  T
## 5  L  S  A  T
```

1.6 Random-Number Tables

```r
#generate 15 random integers between 1 and 728
sample(1:728, 15)
```

```
##  [1] 418 204  25 556 649 355 149  80 479 245 129 462 325 259 383
```

1.7 Systematic Random Sampling

```r
#declare variables
pop <- 728
sos <- 15
division <- floor(pop / sos)
division
```

```
## [1] 48
```

```r
start <- sample(1:division, 1)
start
```

```
## [1] 8
```

```r
#generate sequence
s <- seq(start, pop, division)
s
```

```
##  [1]   8  56 104 152 200 248 296 344 392 440 488 536 584 632 680 728
```

1.8

1.9

1.10

1.11

1.12

1.13

2 Organizing Data

2.1 Variables and Data

This example contains no code.

2.2 Variables and Data

This example contains no code.

2.3 Variables and Data

This example contains no code.

2.4 Variables and Data

This example contains no code.

2.5 Grouping Quantitative Data

```r
#read in the data
invest <- read.csv("data/Tb02-01.txt")
str(invest)
```

```
## 'data.frame': 40 obs. of  1 variable:
##  $ DAYS: int  70 64 99 55 64 89 87 65 62 38 ...
```

```r
w <- cut(invest$DAYS, c(30, 40, 50, 60, 70, 80, 90, 100), right = FALSE)
invest$CAT <- w
table(invest$CAT)
```

```
##
##  [30,40)  [40,50)  [50,60)  [60,70)  [70,80)  [80,90) [90,100)
##        3        1        8       10        7        7        4
```

```r
x <- table(invest$CAT)
y <- prop.table(x)
z <-  merge(x, y, by.x = "Var1", by.y = "Var1")
z
```

```
##       Var1 Freq.x Freq.y
## 1  [30,40)      3  0.075
## 2  [40,50)      1  0.025
## 3  [50,60)      8  0.200
## 4  [60,70)     10  0.250
## 5  [70,80)      7  0.175
## 6  [80,90)      7  0.175
## 7 [90,100)      4  0.100
```

```r
mu <- 100
sigma <- 16
ptile <- qnorm(0.90, mu, sigma)
ptile
```

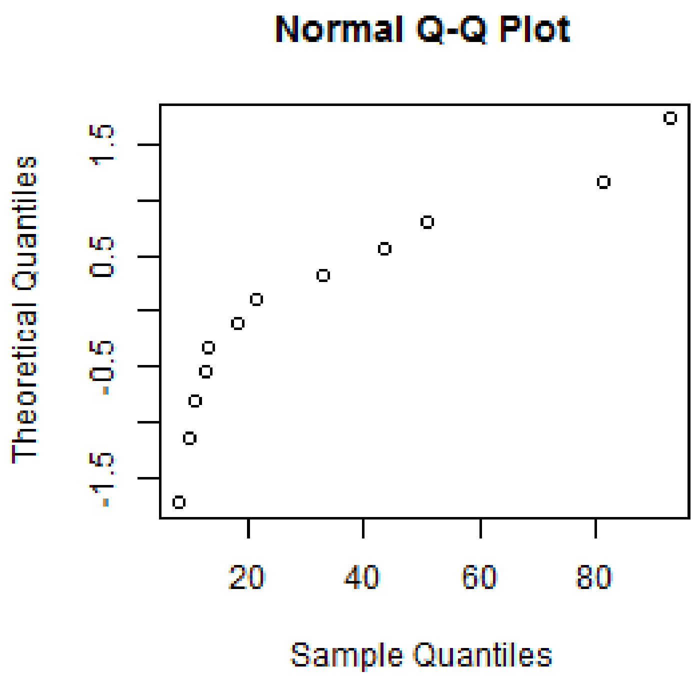
```
## [1] 120.5
```

6.14 Example 6.14, Normal Probability Plots

```r
#read in the data
income <- read.csv("data/Tb06-03.txt")
str(income)
```

```
## 'data.frame': 12 obs. of  1 variable:
##  $ AGI: num  9.7 93.1 33 21.2 81.4 51.1 43.5 10.6 12.8 7.8 ...
```

```r
qqnorm(income$AGI, datax = TRUE)
```



7 The Sampling Distribution of the Sample Mean

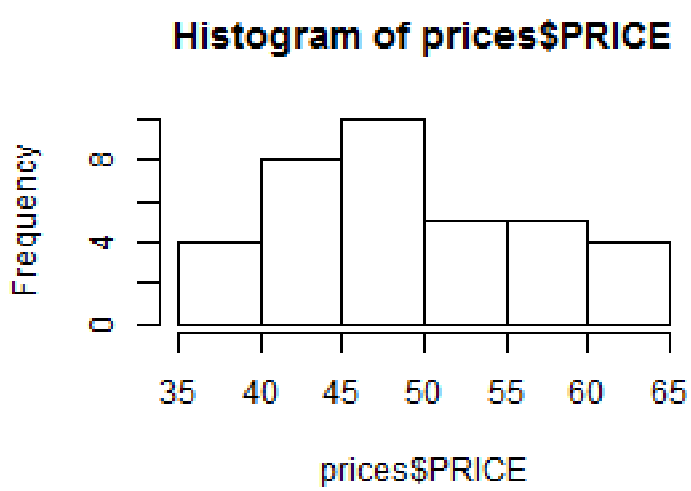
8 Confidence Intervals for One Population Mean

8.1 Example 8.1, Estimating a Population Mean

```
#read in the data
prices <- read.csv("data/Tb08-01.txt")
str(prices)
```

```
## 'data.frame': 36 obs. of  1 variable:
##  $ PRICE: num  53.8 54.4 45.2 42.9 49.9 48.2 41.6 58.9 48.6 53.1 ...
```

```
hist(prices$PRICE, breaks = 5)
```




```
sum <- sum(prices$PRICE)
n <- nrow(prices)
mu <- sum / n
#alternatively
mu1 <- mean(prices$PRICE)
```

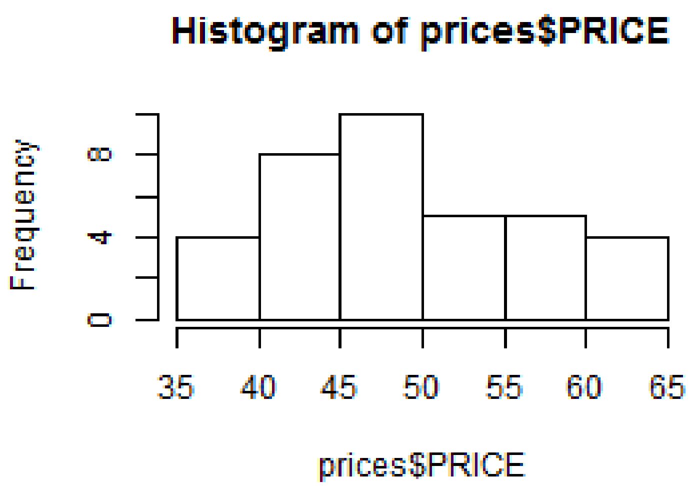
The estimated population, μ, from the sample mean, $\bar{x}$, is 49.2778.

8.2 Example 8.2, Introducing Confidence Intervals

```r
#read in the data
prices <- read.csv("data/Tb08-01.txt")
str(prices)
```

```
## 'data.frame': 36 obs. of  1 variable:
##  $ PRICE: num  53.8 54.4 45.2 42.9 49.9 48.2 41.6 58.9 48.6 53.1 ...
```

```r
hist(prices$PRICE, breaks = 5)
```




```r
sum <- sum(prices$PRICE)
n <- nrow(prices)
mu <- sum / n
sigma <- 7.2
s <- sigma / sqrt(n)
cat(sum, n, mu, sigma, s)
```

```
## 1774 36 49.28 7.2 1.2
```

```r
confidence.interval <- simple.z.test(prices$PRICE, sigma, conf.level = 0.9544)
confidence.interval
```

```
## [1] 46.88 51.68
```

8.3 Example 8.3, Interpreting Confidence Intervals

8.4 Example 8.4, The One-Sample z-Interval Procedure

8.5 Example 8.5, Using Technology to Obtain a z-Interval

8.6 Example 8.6, Introducing the Margin of Error

8.7 Example 8.7, Sample Size for Estimating μ

8.8 Example 8.8, Finding the t-Value Having a Specified Area to the Right

8.9 Example 8.9, The One-Sample t-Interval Procedure

8.10 Example 8.10, The One-Sample t-Interval Procedure

8.11 Example 8.11, Choosing a Confidence Interval Procedure

9 Hypothesis Tests for One Population Mean

9.1 Example 9.1, Choosing the Null and Alternative Hypotheses

This example contains no code.

9.2 Example 9.2, Choosing the Null and Alternative Hypotheses

This example contains no code.

9.3 Example 9.3, Choosing the Null and Alternative Hypotheses

This example contains no code.

9.4 Example 9.4, The Logic of Hypothesis Testing

Null hypothesis is $H_0 : \mu = 454$.
Alternative hypothesis is $H_\alpha : \mu \neq 454$.

```
# load the data file
weights <- read.csv("data/Tb09-01.txt")
str(weights)

## 'data.frame': 25 obs. of  1 variable:
##  $ WEIGHT: int  465 456 438 454 447 449 442 449 446 447 ...

#declare and initialize variables
mu <- 454
sigma <- 7.8
n <- 25
xbar <- mean(weights$WEIGHT)
ztest <- (xbar - mu) / (sigma / sqrt(n))
ztest

## [1] -2.564

#determine the result of the test
result <- pnorm(ztest)
result

## [1] 0.005172

#use simple z test from UsingR package
library(UsingR)
conf.int <- simple.z.test(weights$WEIGHT, sigma = sigma, conf.level = 0.9544)
conf.int

## [1] 446.9 453.1
```

The claimed weight of the population is μ per bag, 454 grams. The mean sample weight is $\bar{x}$ per bag, 450 grams. The z value is -2.5641, which is more than two standard deviations below the population mean.

9.5 Example 9.5, Type I and Type II Errors

This example contains no code.

9.6 Example 9.6, Obtaining the Critical Values

```
left.tail <- qnorm(0.05)
left.tail

## [1] -1.645

right.tail <- qnorm(0.95)
right.tail
```

```
## [1] 1.645

two.tail.left <- qnorm(0.025)
two.tail.left

## [1] -1.96

two.tail.right <- qnorm(0.975)
two.tail.right

## [1] 1.96
```

9.7 Example 9.7, The One-Sample z-Test

Null hypothesis is $H_0 : \mu = \$51.46$.
Alternative hypothesis is $H_\alpha :> \$51.46$

```
# load the data file
books <- read.csv("data/Tb09-05.txt")
str(books)

## 'data.frame': 40 obs. of  1 variable:
##  $ PRICE: num  56 46.2 47.3 54 53.7 ...

#declare and initialize variables
mu <- 51.46
sigma <- 7.61
n <- 40
xbar <- mean(books$PRICE)
right.tail = 0.01
ztest <- (xbar - mu) / (sigma / sqrt(n))
ztest

## [1] 2.851

right.crit <- qnorm(1 - right.tail)
right.crit

## [1] 2.326
```

The z statistic is 2.8508, which is greater than the critical value of 2.3263, so we reject the null hypothesis.

9.8 Example 9.8, The One-Sample z-Test

Null hypothesis is $H_0 : \mu = 800$.
Alternative hypothesis is $H_\alpha :< 800$

```
# load the data file
rda <- read.csv("data/Tb09-06.txt")
str(rda)

## 'data.frame': 18 obs. of  1 variable:
##  $ CALCI: int  686 433 743 647 734 641 993 620 574 634 ...
```

```r
#declare and initialize variables
mu <- 800
sigma <- 188
n <- 18
xbar <- mean(rda$CALCI)
left.tail = 0.05
ztest <- (xbar - mu) / (sigma / sqrt(n))
ztest
```

```
## [1] -1.187
```

```r
left.crit <- qnorm(left.tail)
left.crit
```

```
## [1] -1.645
```

The z statistic is -1.1873, which is less than the critical value of -1.6449, so we do not reject the null hypothesis.

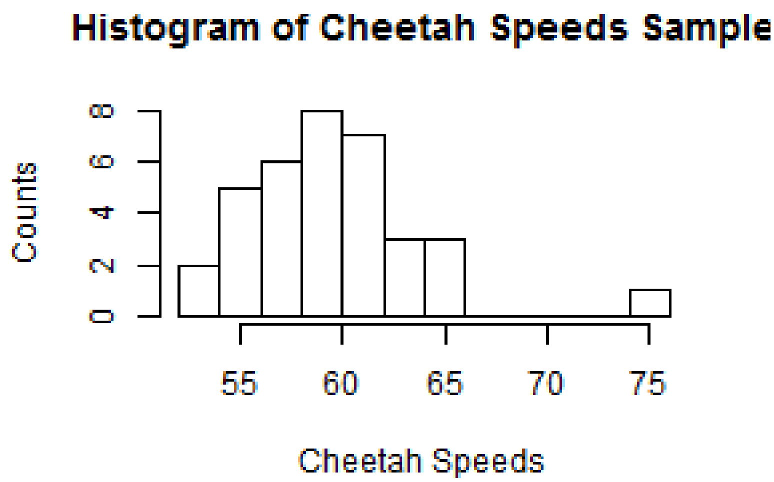
9.9 Example 9.9, The One-Sample z-Test

Null hypothesis is $H_0 : \mu = 60$.
Alternative hypothesis is $H_\alpha :\neq 60$

```r
# load the data file
cheetah <- read.csv("data/Tb09-07.txt")
str(cheetah)
```

```
## 'data.frame': 35 obs. of  1 variable:
##  $ SPEEDS: num  57.3 57.5 59 56.5 61.3 57.6 59.2 65 60.1 59.7 ...
```

```r
#histogram of the data set
hist(cheetah$SPEEDS, breaks = 15, xlab = "Cheetah Speeds", ylab = "Counts", main = "Histogram of
```




```r
#declare and initialize variables
mu <- 60
sigma <- 3.2
n <- 35
xbar <- mean(cheetah$SPEEDS)
tails = 0.05
ztest <- (xbar - mu) / (sigma / sqrt(n))
ztest

## [1] -0.8768

crits <- qnorm(c( tails / 2, (1 - tails / 2)))
crits

## [1] -1.96  1.96
```

The z statistic is -0.8768, which is less than the critical values of -1.96, 1.96, so we do not reject the null hypothesis.

9.10 Example 9.10,

9.11 Example 9.11,

9.12 Example 9.12,

9.13 Example 9.13,

9.14 Example 9.14,

9.15 Example 9.15,

9.16 Example 9.16,

9.17 Example 9.17,

9.18 Example 9.18,

9.19 Example 9.19,

9.20 Example 9.20,

9.21 Example 9.21,

10 Inferences for Two Population Means

11 Inferences for Population Standard Deviations

12 Inferences for Population Proportions

13 Chi-Square Procedures

14 Descriptive Methods in Regression and Correlation

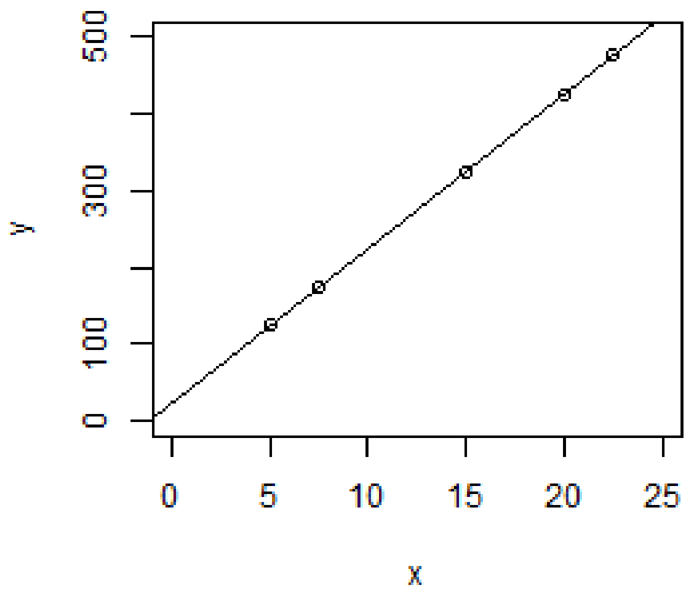
14.1 Linear Equations

```
# load the data file
wp <- read.csv("data/Tb14-01.txt", sep = "\t")
str(wp)
```

```
## 'data.frame': 5 obs. of  2 variables:
##  $ TIME: num  5 7.5 15 20 22.5
##  $ COST: int  125 175 325 425 475
```

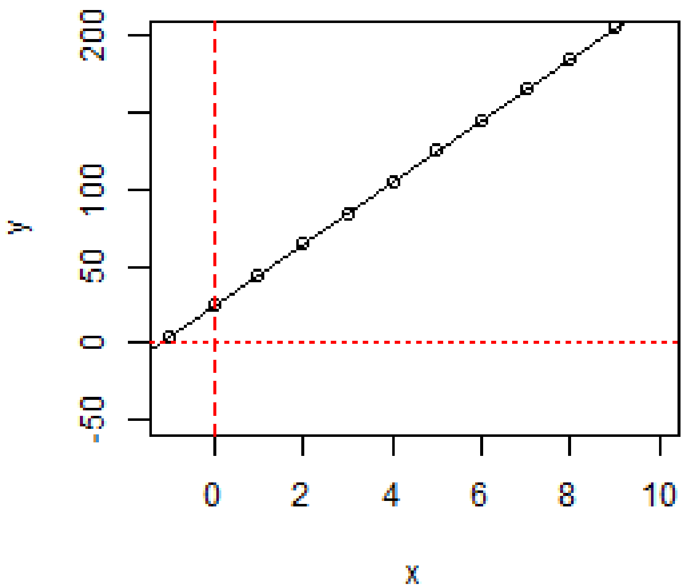
```
x <- wp$TIME
y <- 25 + (20 * x)
line <- lm(y ~ x)
```

```
plot(x, y, xlim = c(0,25), ylim = c(0,500))
abline(line)
```



14.2 y-Intercept and Slope

```
# load dummy data
x <- c(-1:10)
y <- 25 + (20 * x)
line <- lm(y ~ x)
plot(x, y, xlim = c(-1,10), ylim = c(-50,200))
abline(line)
abline(v=0,col="red", lty = 2)
abline(h=0,col="red", lty = 3)
```



14.3 Introducing the Least Squares Criterion

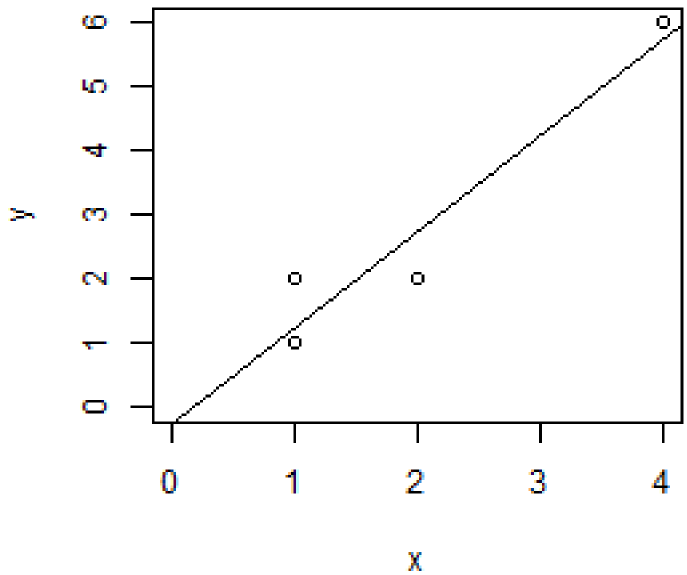
```
x <- c(1,1,2,4)
y <- c(1,2,2,6)
df <- data.frame(x,y)
df

##   x y
## 1 1 1
## 2 1 2
## 3 2 2
## 4 4 6

plot(df, xlim = c(0, 4), ylim = c(0, 6))
line <- lm(y ~ x)
line

##
## Call:
## lm(formula = y ~ x)
##
## Coefficients:
## (Intercept)            x
##       -0.25         1.50
```

```r
abline(line)
```



14.4 The Regression Equation

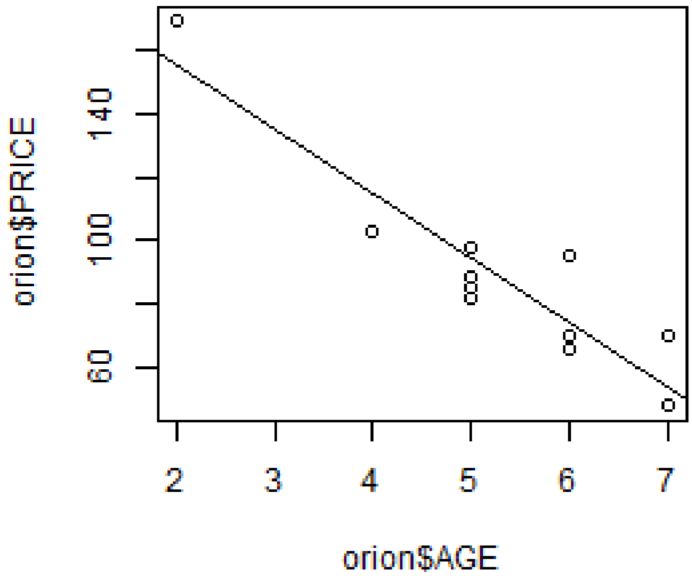
```r
# load Orion data
orion <- read.csv("data/Tb14-02.txt", sep = "\t")
str(orion)
```

```
## 'data.frame': 11 obs. of  2 variables:
##  $ AGE  : int  5 4 6 5 5 5 6 6 2 7 ...
##  $ PRICE: int  85 103 70 82 89 98 66 95 169 70 ...
```

```r
s <- lm(orion$PRICE ~ orion$AGE)
s
```

```
##
## Call:
## lm(formula = orion$PRICE ~ orion$AGE)
##
## Coefficients:
## (Intercept)    orion$AGE
##       195.5        -20.3
```

```r
plot(orion$AGE, orion$PRICE)
abline(s)
```




```
# find y for x equals 3 and 4
s$coefficients
```

```
## (Intercept)   orion$AGE
##      195.47      -20.26
```

```
intercept <- s$coefficients[[1]]
slope <- s$coefficients[[2]]
three.year.old.Orion <- intercept + ( slope * 3)
three.year.old.Orion
```

```
## [1] 134.7
```

```
four.year.old.Orion <- intercept + ( slope * 4)
four.year.old.Orion
```

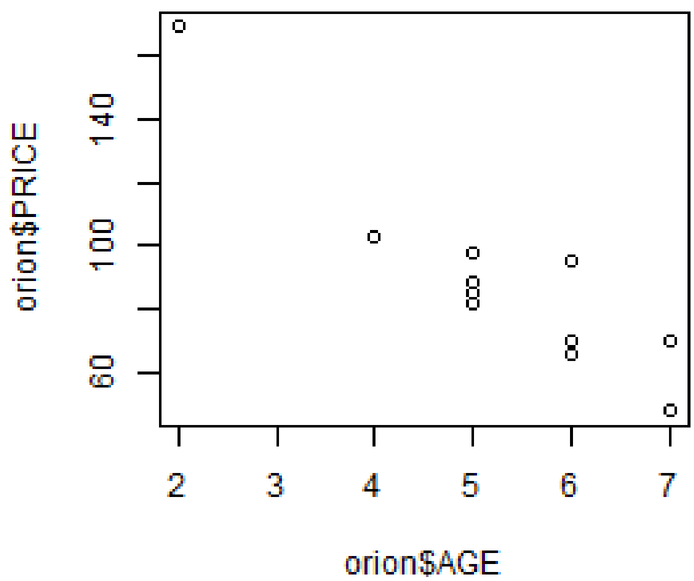
```
## [1] 114.4
```

14.5 Using Technology to Obtain a Scatter Diagram

```
# load Orion data
orion <- read.csv("data/Tb14-02.txt", sep = "\t")
str(orion)
```

```
## 'data.frame': 11 obs. of  2 variables:
##  $ AGE  : int  5 4 6 5 5 5 6 6 2 7 ...
##  $ PRICE: int  85 103 70 82 89 98 66 95 169 70 ...
```

```
plot(orion$AGE, orion$PRICE)
```



14.6 Using Technology to Obtain a Regression Line

```
# load Orion data
orion <- read.csv("data/Tb14-02.txt", sep = "\t")
str(orion)
```

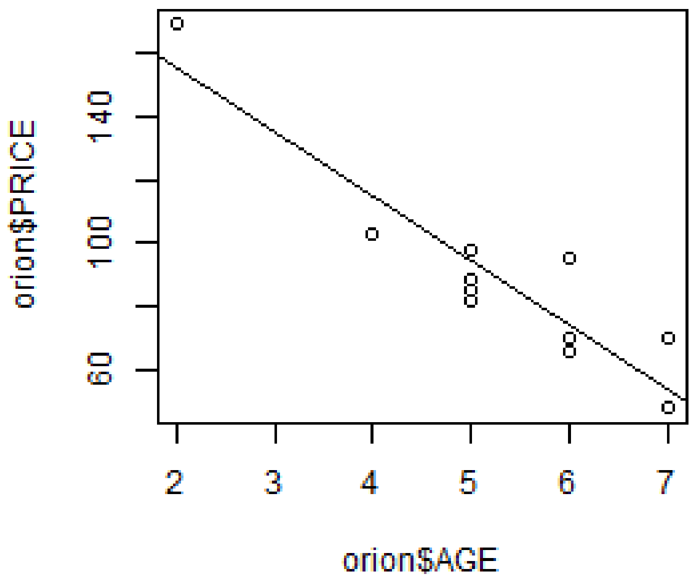
```
## 'data.frame': 11 obs. of  2 variables:
##  $ AGE  : int  5 4 6 5 5 5 6 6 2 7 ...
##  $ PRICE: int  85 103 70 82 89 98 66 95 169 70 ...
```

```
s <- lm(orion$PRICE ~ orion$AGE)
s
```

```
##
## Call:
## lm(formula = orion$PRICE ~ orion$AGE)
```

```
##
## Coefficients:
## (Intercept)    orion$AGE
##       195.5        -20.3
```

```
plot(orion$AGE, orion$PRICE)
abline(s)
```



14.7 Introduces the Coefficient of Determination

```
# load Orion data
orion <- read.csv("data/Tb14-02.txt", sep = "\t")
str(orion)
```

```
## 'data.frame': 11 obs. of  2 variables:
##  $ AGE  : int  5 4 6 5 5 5 6 6 2 7 ...
##  $ PRICE: int  85 103 70 82 89 98 66 95 169 70 ...
```

```
y.sub.ybar <- orion$PRICE - mean(orion$PRICE)
y.sub.ybar
```

```
##  [1]  -3.6364  14.3636 -18.6364  -6.6364   0.3636   9.3636 -22.6364
##  [8]   6.3636  80.3636 -18.6364 -40.6364
```

```
y.sub.ybar.sqr <- y.sub.ybar^2
y.sub.ybar.sqr
```

```
##  [1]   13.2231  206.3140  347.3140   44.0413    0.1322   87.6777  512.4050
##  [8]   40.4959 6458.3140  347.3140 1651.3140
```

```
t <- data.frame(orion,y.sub.ybar,y.sub.ybar.sqr)
s <- lm(orion$PRICE ~ orion$AGE)
yhat <- s$coefficients[[1]] + (s$coefficients[[2]] * t$AGE)
t$yhat <- yhat
yhat.sub.ybar <- t$yhat - mean(t$PRICE)
t$yhat.sub.ybar <- yhat.sub.ybar
y.sub.yhat.sqr <- (t$PRICE - t$yhat)^2
t$y.sub.yhat.sqr <- y.sub.yhat.sqr
yhat.sub.ybar.sqr <- (yhat - mean(t$PRICE))^2
t$yhat.sub.ybar.sqr <- yhat.sub.ybar.sqr
t
```

```
##    AGE PRICE y.sub.ybar y.sub.ybar.sqr   yhat yhat.sub.ybar y.sub.yhat.sqr
## 1    5    85    -3.6364        13.2231  94.16         5.526          83.95
## 2    4   103    14.3636       206.3140 114.42        25.787         130.49
## 3    6    70   -18.6364       347.3140  73.90       -14.735          15.22
## 4    5    82    -6.6364        44.0413  94.16         5.526         147.92
## 5    5    89     0.3636         0.1322  94.16         5.526          26.65
## 6    5    98     9.3636        87.6777  94.16         5.526          14.73
## 7    6    66   -22.6364       512.4050  73.90       -14.735          62.42
## 8    6    95     6.3636        40.4959  73.90       -14.735         445.17
## 9    2   169    80.3636      6458.3140 154.95        66.310         197.52
## 10   7    70   -18.6364       347.3140  53.64       -34.997         267.66
## 11   7    48   -40.6364      1651.3140  53.64       -34.997          31.81
##    yhat.sub.ybar.sqr
## 1              30.53
## 2             664.97
## 3             217.13
## 4              30.53
## 5              30.53
## 6              30.53
## 7             217.13
## 8             217.13
## 9            4396.96
## 10           1224.77
## 11           1224.77
```

```
sst <- sum(t$y.sub.ybar.sqr)
sst
```

```
## [1] 9709
```

```
ssr <- sum((t$yhat - mean(t$PRICE))^2)
ssr
```

```
## [1] 8285
```

```
r.sqrd <- ssr / sst
r.sqrd
```

```
## [1] 0.8534
```

```
sse <- sum((t$PRICE - t$yhat)^2)
sse
```

```
## [1] 1424
```

14.8 Computing Formulas for the Sum of Squares

```
# load Orion data
orion <- read.csv("data/Tb14-02.txt", sep = "\t")
str(orion)
```

```
## 'data.frame': 11 obs. of  2 variables:
##  $ AGE  : int  5 4 6 5 5 5 6 6 2 7 ...
##  $ PRICE: int  85 103 70 82 89 98 66 95 169 70 ...
```

```
xx <- orion$AGE^2
yy <- orion$PRICE^2
xy <- orion$AGE * orion$PRICE
t <- data.frame(orion, xx, yy, xy)
t
```

```
##    AGE PRICE xx    yy  xy
## 1    5    85 25  7225 425
## 2    4   103 16 10609 412
## 3    6    70 36  4900 420
## 4    5    82 25  6724 410
## 5    5    89 25  7921 445
## 6    5    98 25  9604 490
## 7    6    66 36  4356 396
## 8    6    95 36  9025 570
## 9    2   169  4 28561 338
## 10   7    70 49  4900 490
## 11   7    48 49  2304 336
```

```
sum.x <- sum(t$AGE)
sum.y <- sum(t$PRICE)
sum.xx <- sum(t$xx)
sum.yy <- sum(t$yy)
sum.xy <- sum(t$xy)
sst <- sum.yy - (sum.y^2 / nrow(t))
sst
```

```
## [1] 9709
```

```
num <- (sum.xy - (sum.x * sum.y / nrow(t)))^2
den <- sum.xx - sum.x^2 / nrow(t)
ssr <- num / den
ssr
```

```
## [1] 8285
sse <- sst - ssr
sse
## [1] 1424
```

14.9 Using Technology to Obtain a Coefficient of Determination

```
# read in the data
orion <- read.csv("data/Tb14-02.txt", sep = "\t")
str(orion)
## 'data.frame': 11 obs. of  2 variables:
##  $ AGE  : int  5 4 6 5 5 5 6 6 2 7 ...
##  $ PRICE: int  85 103 70 82 89 98 66 95 169 70 ...
s <- lm(orion$PRICE ~ orion$AGE)
summary(s)
##
## Call:
## lm(formula = orion$PRICE ~ orion$AGE)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -12.16  -8.53  -5.16   8.95  21.10
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)    195.5       15.2   12.83  4.4e-07 ***
## orion$AGE      -20.3        2.8   -7.24  4.9e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.6 on 9 degrees of freedom
## Multiple R-squared:  0.853,Adjusted R-squared:  0.837
## F-statistic: 52.4 on 1 and 9 DF,  p-value: 4.88e-05
summary(s)$r.squared
## [1] 0.8534
```

14.10

14.11

15 Inferential Methods in Regression and Correlation

16 Analysis of Variance (ANOVA)